

JAN 10 1947

Inactive

R.A. 1375

~~CONFIDENTIAL~~

RM No. L6L17a

NAVY LIBRARY

NACA

RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Navy Department

FLIGHT-TEST EVALUATION OF THE LONGITUDINAL STABILITY
AND CONTROL CHARACTERISTICS OF 0.5-SCALE MODELS OF
THE FAIRCHILD LARK PILOTLESS-AIRCRAFT CONFIGURATION.
STATIC LONGITUDINAL STABILITY OF MODELS WITH
WING FLAP DEFLECTIONS OF 0° AND 15°

TEST NO. NACA 2387

By

David G. Stone

13 January 1947

CLASSIFIED DOCUMENT

This document contains classified information affecting the national defense of the United States within the meaning of the Espionage Act, 18 USC 793 and 794, the transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law. Information so classified may be imparted only to persons in the military and naval services of the United States, appropriate civilian officers and employees of the Federal Government who have a legitimate interest therein, and to United States citizens of known loyalty and discretion who if necessary must be informed thereof.

**NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS**

WASHINGTON

CLASSIFICATION CHANGED

UNCLASSIFIED

To

T.W. Crowley per
By authority of NACA. Release Form Date 3-15-55
2955 Dec 3-2-55

~~CONFIDENTIAL~~



NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Navy Department

FLIGHT-TEST EVALUATION OF THE LONGITUDINAL STABILITY

AND CONTROL CHARACTERISTICS OF 0.5-SCALE MODELS OF

THE FAIRCHILD LARK PILOTLESS-AIRCRAFT CONFIGURATION.

STATIC LONGITUDINAL STABILITY OF MODELS WITH

WING FLAP DEFLECTIONS OF 0° AND 15°

TED NO. NACA 2387

By David G. Stone

SUMMARY

From flight tests of 0.5-scale models of the Fairchild Lark pilotless aircraft conducted at the flight test station of the Pilotless Aircraft Research Division at Wallops Island, Va., some evaluations of the static longitudinal stability were obtained by analysis of the short-period oscillations induced by the abrupt movement of the rudder elevators. The analysis shows that for the Lark configuration with wing flap deflections of 0° and 15° the static longitudinal stability decreases slightly up to the critical Mach number and then as the Mach number increases further the stability increases greatly.

INTRODUCTION

The National Advisory Committee for Aeronautics was requested by the Bureau of Aeronautics, Navy Department, to make flight tests of the Fairchild Lark pilotless-aircraft configuration to evaluate the longitudinal stability and control characteristics at high subsonic speeds in order to predict the behavior of the full-scale

aircraft. To obtain this information 0.5-scale models, externally geometrically similar to the Fairchild Lark were constructed and flown at the flight test station of the Pilotless Aircraft Research Division at Wallops Island, Va. The results reported herein pertain to the static longitudinal stability of the Lark configuration with wing flap deflections of 0° and 15° .

SYMBOLS

M	free-stream Mach number
C_N	normal force coefficient
$\frac{dM}{d\alpha}$	rate of change of pitching moment with angle of attack, foot-pounds per radian
$\frac{dC_m}{d\alpha}$	rate of change of pitching-moment coefficient with angle of attack, per degree
$\frac{dC_L}{d\alpha}$	rate of change of lift coefficient with angle of attack, per degree
P	period of oscillation, seconds
I_y	moment of inertia about Y-axis, slug-feet ²
q	free-stream dynamic pressure
p	free-stream static pressure
W	weight of model, pounds
S	horizontal wing area, 2.725 square feet
c	wing chord, 0.883 feet
a_n	normal acceleration, feet per second ²
g	acceleration of gravity, 32.2 feet per second ²
δ_f	deflection of horizontal wing flaps, degrees
γ	specific heat ratio; value taken, 1.4

MODELS

The simplified 0.5-scale models used in this investigation were externally geometrical similar to the full-scale Mark (KAQ-1) of the Pilotless Plane Division of the Fairchild Engine and Airplane Corporation. Descriptions of the models and the testing technique are given in references 1 and 2, which report the flight tests of models with $\delta_F = 0^\circ$ and $\delta_F = 15^\circ$. Figure 1 presents the general arrangement of the 0.5-scale models. Table I gives a comparison of the weight and balance characteristics of the models and the full-scale aircraft. A photograph of a model and rocket motor is shown in figure 2.

METHOD OF ANALYSIS

Evaluations of the static longitudinal stability were obtained by analysis of the short-period oscillations induced by the abrupt movement of the rudder elevators. As shown in references 1 and 2 these short-period oscillations appeared in the normal acceleration curve as the normal accelerometer was mounted approximately 3 inches (0.283 chord) ahead of the center of gravity. These short-period oscillations were always damped which indicates the pitching motions to be statically and dynamically stable. The period of the motion for small amplitudes may be expressed as a function of the moment of inertia and the restoring moment per radian movement with respect to the relative wind as follows:

$$P = 2\pi \sqrt{\frac{I_y}{\frac{dM}{d\alpha}}} \quad (1)$$

$$\frac{dC_m}{d\alpha} = - \frac{4\pi^2 I_y}{(57.3) P^2 q S c} \quad (2)$$

The second order effects, such as the amplitude of the oscillation, were found to have no appreciable effect on the value of the period. However, the effect of damping in pitch is not included and, if the damping factor is large some error may be expected. The values

of $\frac{dC_m}{d\alpha}$ obtained are for the model-flight center-of-gravity locations which for $\delta_f = 0^\circ$ varied from 16.0 to 17.4 percent chord and for $\delta_f = 15^\circ$ varied from 19.0 to 19.8 percent chord as the rocket motor burned out. A similar variation of the moment of inertia was included in the computation of $\frac{dC_m}{d\omega}$ for each case.

DISCUSSION

The values of the period determined from the flight tests reported in references 1 and 2 are presented in figure 3 to show the variation of the period of the oscillation with Mach number. The scatter of the test points on figure 3 indicates the amount of error in determining P. As shown in figure 3 for $\delta_f = 15^\circ$ the periods of the oscillations for high and low values of C_N were of different magnitude which indicates different amounts of static stability. For the case of $\delta_f = 0^\circ$ the values of C_N are between -0.3 and 0.4, and for the case of $\delta_f = 15^\circ$ the low values of C_N are between 0 and 0.2 and the high values of C_N are in the vicinity of 0.9.

Figure 4 presents the static longitudinal stability, as computed using equation (2), as a function of Mach number. These curves indicate that as M increases the stability decreases slightly, then as M increases further the stability increases greatly, especially after the critical Mach number. These data indicate that the static longitudinal stability changes rapidly with lift coefficient and Mach number. This is also shown in reference 3, high-speed wind-tunnel tests of a 0.25-scale model.

For $\delta_f = 0^\circ$ an increase in the value of $\frac{dC_m}{d\alpha}$ from -0.03 to -0.053 may be expected as M changes from 0.6 to 0.9, and for $\delta_f = 15^\circ$ (high C_N) an increase in the value of $\frac{dC_m}{d\alpha}$ from -0.018 to -0.037 may be expected as M changes from 0.7 to 0.8.

By taking the value of the slope of the lift curve $\frac{dC_L}{d\alpha}$ to be 0.08, an average value as determined from reference 3, and also including the variation of center of gravity, the neutral points were computed for these conditions. These neutral points,

of course, do not include the probable changes in $\frac{dC_L}{d\alpha}$ beyond the critical Mach number. The variation of the neutral points for $\delta_f = 0^\circ$ and $\delta_f = 15^\circ$ with M is given in figure 5. Again the increase in stability is indicated by the large rearward movement of the neutral point as M increases above 0.75.

CONCLUSIONS

The period of the short-period oscillation induced by the abrupt movement of the rudder elevators can be used to give quantitative information on the static longitudinal stability. For the 0.5-scale model Lark with wing flap deflections of 0° and 15° the static longitudinal stability decreased slightly up to the critical Mach number, then as M increased further the stability increased greatly.

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va.

David G. Stone
David G. Stone
Aeronautical Engineer

Approved:

Robert R. Gilruth
Robert R. Gilruth

Chief of Pilotless Aircraft Research Division

bw

REFERENCES

1. Stone, David G., and Mitcham, Grady L.: Flight-Test Evaluation of the Longitudinal Stability and Control Characteristics of 0.5-Scale Models of the Fairchild Lark Pilotless-Aircraft Configuration. Model with Wing Flaps Not Deflected - TED No. NACA 2387. NACA MR No L6H22, Bur. Aero., 1946.
2. Stone, David G.: Flight-Test Evaluation of the Longitudinal Stability and Control Characteristics of 0.5-Scale Models of the Fairchild Lark Pilotless-Aircraft Configuration. Model with Wing Flaps Deflected 15° - TED No. NACA 2387. NACA RM No. L6J28a, Bur. Aero., 1946.
3. Smith, Norman F.: High-Speed Tests of $\frac{1}{4}$ -Scale Model of Navy Special Missile Lark. NACA MR No. L5H01, Bur. Aero., 1945.

TABLE I

Item	Full-scale aircraft	Model flight no. 1		Model flight no. 2	
		At take-off	At burn-out	At take-off	At burn-out
Weight, lb	1060	124.7	97.3	127.4	99.9
Center-of-gravity location, percent chord	20	15.2	17.4	18.6	19.8
Wing loading lb/sq ft	110	45.7	35.7	46.7	36.6
Moment of inertia slug-feet ²	221(approx.)	8.9	8.5	8.3	7.9
Radius of gyration, ft	2.6(approx.)	1.5	1.7	1.45	1.59

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

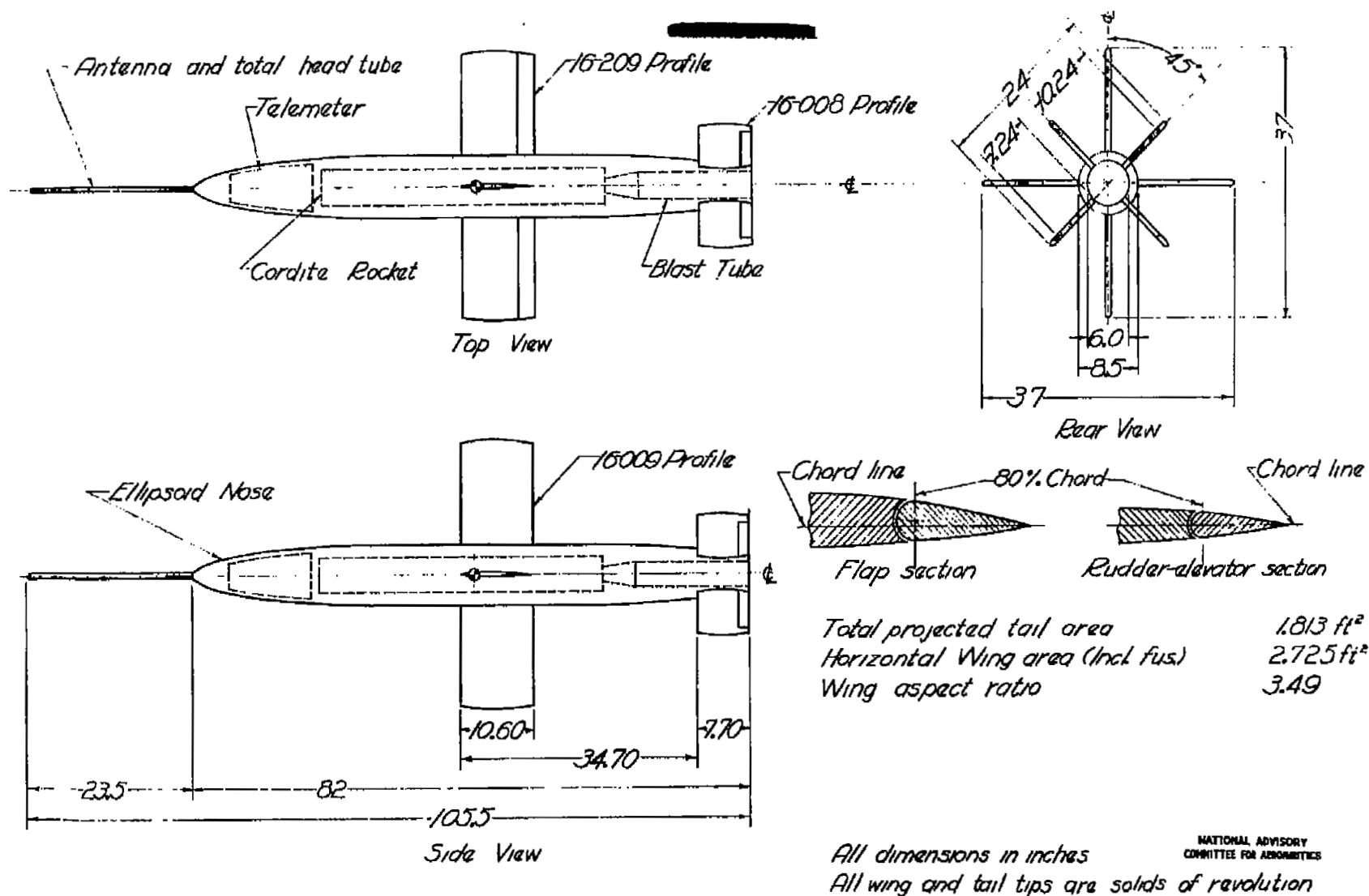


Figure 1.-Three view drawing of 0.5-scale model of Fairchild Lark Pilotless Aircraft.

1955

CONFIDENTIAL

NACA RM No. L6L17a

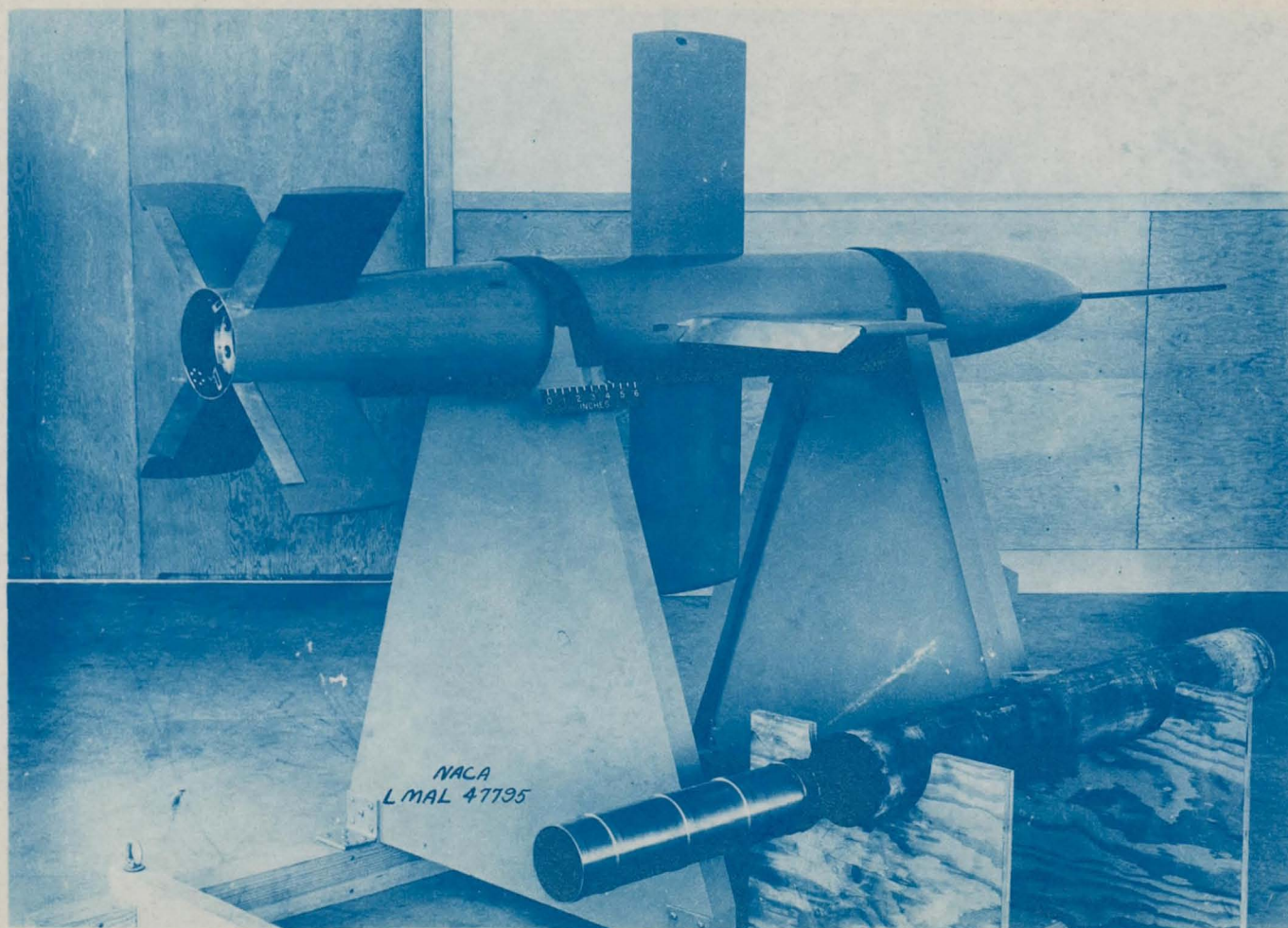


Figure 2.- Photograph of a 0.5-scale model Lark and rocket motor with blast tube.

Fig. 2

CONFIDENTIAL

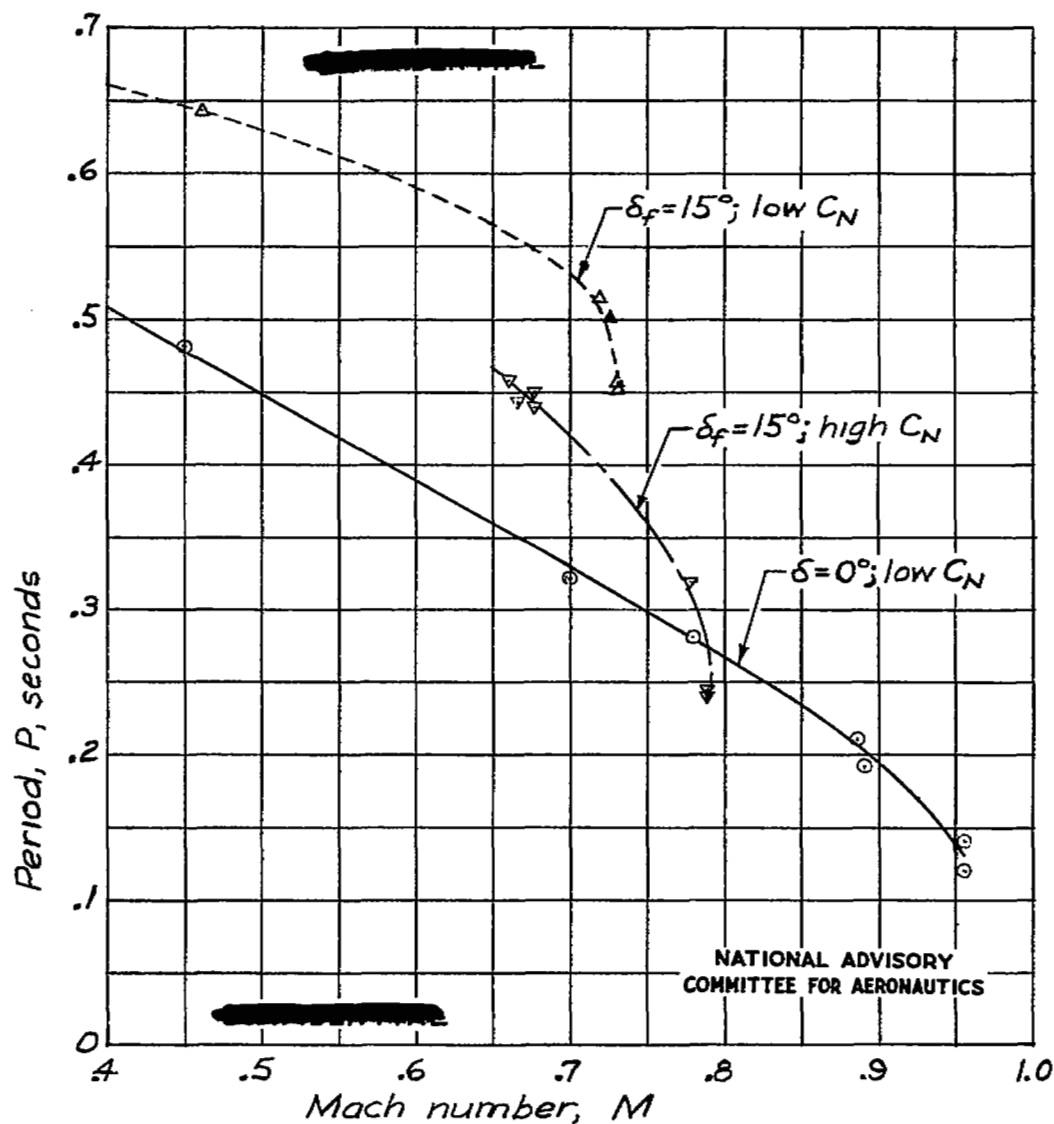


Figure 3.-Variation of period of the short-period oscillations with Mach number for $\delta_f = 0^\circ$ and $\delta_f = 15^\circ$.

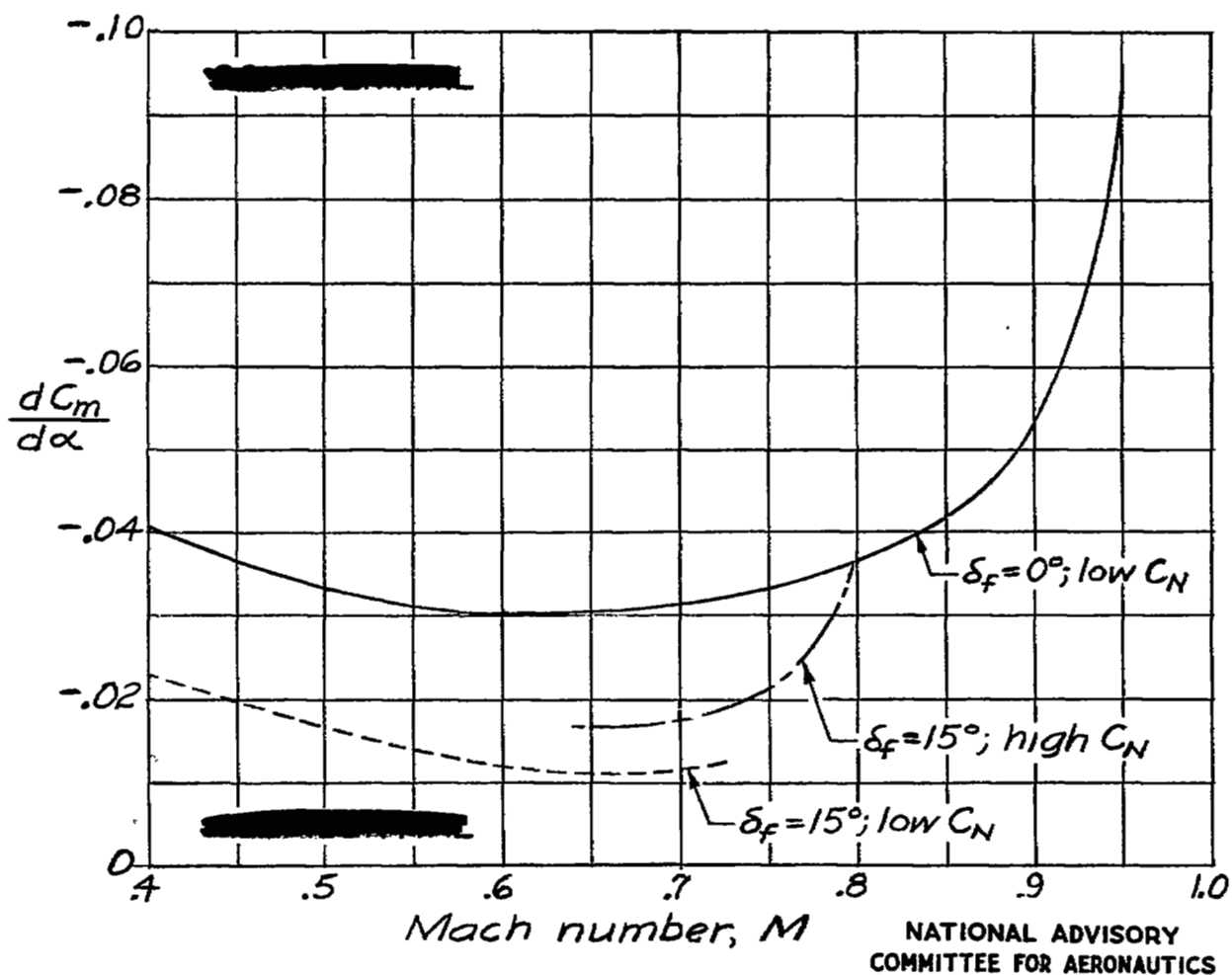


Figure 4.- Variation of the static longitudinal stability with Mach number for $\delta_f = 0^\circ$ and $\delta_f = 15^\circ$.

1968

NACA RM No. L6L17a

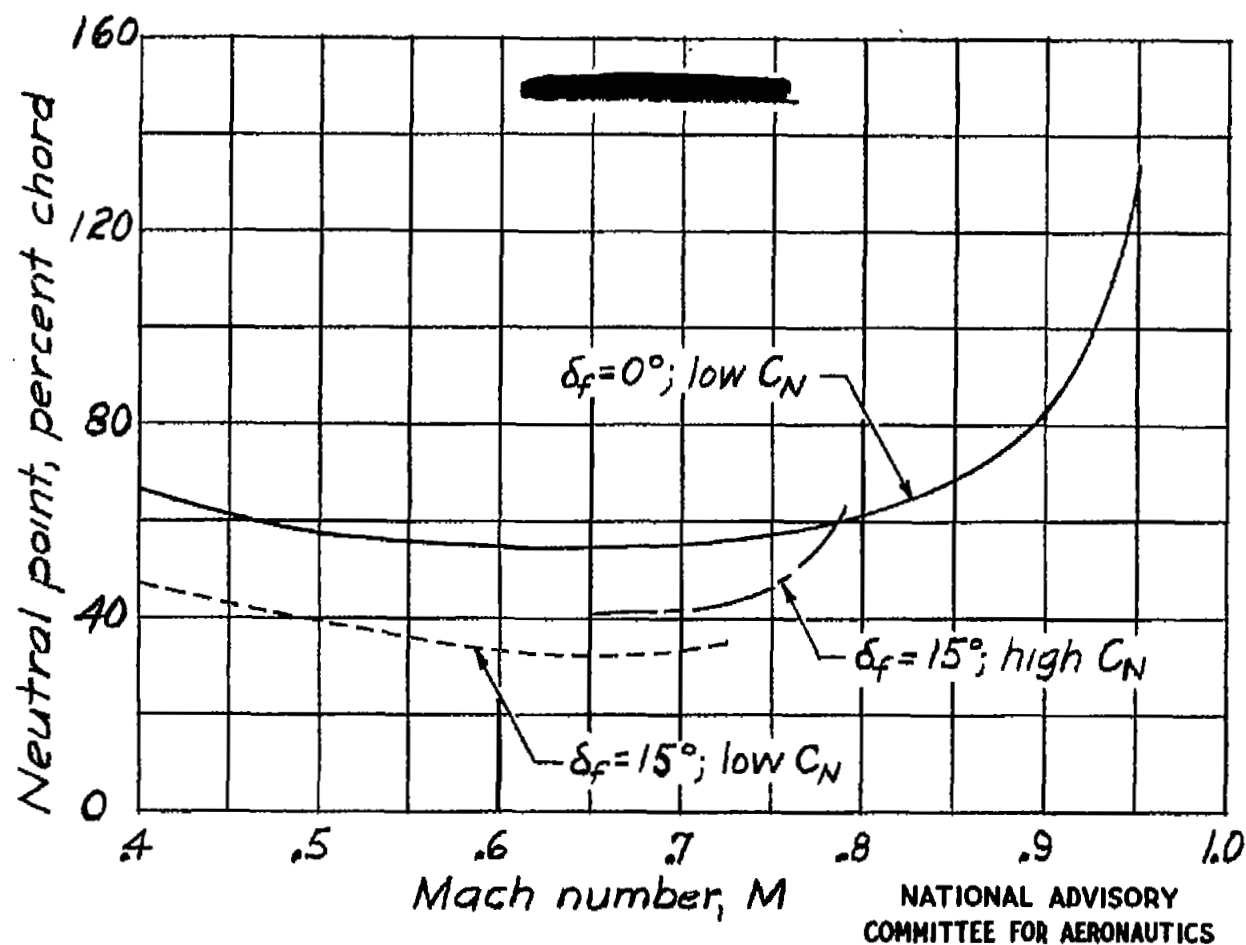


Figure 5.- Variation of the neutral point with Mach number for $\delta_f = 0^\circ$ and $\delta_f = 15^\circ$; $dC_L/d\alpha$ assumed to be 0.08.

Fig. 5

